

**REMARKS**

By this Amendment, Claims 1, 7-10, 41, 42, 51-55 and 58 have been amended, leaving Claims 1-11, 13-15 and 39-61 pending in the application. No new matter has been added by the amendments.

**I. The Affirmed Rejections are Moot**

The following rejections were affirmed by the Board (see the Board Decision at page 3, lines 15-16): **(1)** the rejection of Claims 1-6, 11, 13, 14, 39, 41-43, 47, 48, 50, 56 and 59-61 under 35 U.S.C. § 103(a) over WO 99/57747 to Chang ("Chang") in view of U.S. Patent No. 6,450,117 to Murugesh et al. ("Murugesh"), U.S. Patent No. 5,958,140 to Arami et al. ("Arami"), U.S. Patent No. 5,532,190 to Goodyear et al. ("Goodyear") and U.S. Patent No. 6,090,210 to Ballance et al. ("Ballance"); **(2)** the rejection of Claim 8 under 35 U.S.C. § 103(a) over Chang in view of Murugesh, Arami, Goodyear, Ballance and WO 00/41212 to Ni et al. ("Ni"); **(3)** the rejection of Claim 15 under 35 U.S.C. § 103(a) over Chang in view of Murugesh, Arami, Goodyear, Ballance and U.S. Patent No. 6,287,643 to Powell et al. ("Powell"); and **(4)** the rejection of Claims 51, 54 and 55 under 35 U.S.C. § 103(a) over Chang in view of Murugesh, Arami, Goodyear, Ballance and U.S. Patent No. 4,270,999 to Hassan et al. ("Hassan").

As discussed below, independent Claims 1, 41 and 42 have been amended to recite the features of the off-axis outlets of the gas injector inject gas at an acute angle relative to a plane parallel to an exposed surface of the substrate. At page 13, lines 25-27, of the Board Decision, the Board states:

We further agree with appellants that there is no motivation in the applied references to adjust the off-axis outlets 247 of the

Murugesh FIG. 3 injector to inject gas at an acute angle relative to the plane parallel to the exposed surface of the substrate as required by claim 9. (Emphasis added).

The Board reversed the rejection of Claim 9 (see the Board Decision at page 14, lines 10-11). Consistent with the Board's reversal of the rejection of Claim 9, as result of the amendments to Claims 1, 41 and 42, it is submitted that each of the rejections affirmed by the Board are now moot.

## **II. New Grounds of Rejection Raised by the Board**

The Board raised the following new grounds of rejection: **(1)** Claims 10, 40, 46, 47 and 59 were rejected under 35 U.S.C. § 112, second paragraph (see pages 6-7 of the Board Decision); **(2)** Claims 1-9, 11, 13, 14, 39, 41-50 and 56-61 were rejected under 35 U.S.C. § 103(a) over Ni in view of Chang, Murugesh, Arami, Goodyear and Ballance (see the Board Decision at pages 14-15); **(3)** Claim 15 was rejected under 35 U.S.C. § 103(a) over Ni in view of Chang, Murugesh, Arami, Goodyear, Ballance and Powell (see the Board Decision at pages 15-16); and **(4)** Claims 51-55 were rejected under 35 U.S.C. § 103(a) over Ni in view of Chang, Murugesh, Arami, Goodyear, Ballance and Hassan (see the Board Decision at page 16).

### **A. Rejection Under 35 U.S.C. § 112, ¶ 2**

Claim 10 has been amended to address the reasons for this rejection stated at page 6, line 9 to page 7, line 2, of the Board Decision. Claim 10, as amended, recites the features of "the gas outlets including at least one on-axis outlet and a plurality of off-axis outlets." This amendment provides strict antecedent basis for the

recited features of "the first gas line being in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not with the on-axis outlet."

As a result of the amendment to Claim 10, it is submitted that Claims 10, 40, 46, 47 and 59 are in compliance with 35 U.S.C. § 112, second paragraph. Therefore the rejection has been overcome.

**B. Rejections Under 35 U.S.C. § 103**

Before addressing the new grounds of rejection under 35 U.S.C. § 103, applicable legal standards will be discussed.

**1. Legal Standards for *Prima Facie* Obviousness**

As set forth in *Dickinson v. Zurko*, 527 US 150, 50 USPQ2d 1930 (1999), tribunals of the USPTO are governed by the Administrative Procedure Act and BPAI decisions must be set aside if unsupported by substantial evidence. Rejections under 35 USC §103 must be based on "evidence relevant to the finding of whether there is a teaching, motivation, or suggestion to select and combine the references relied on as evidence of obviousness" *In re Lee*, 277 F3d 1338, 61 USPQ2d 1430, 1434 (Fed. Cir. 2002). A showing of a suggestion, teaching, or motivation to combine the prior art references is an essential component of an obviousness holding and "particular findings must be made as to the reason the skilled artisan, with no knowledge of the claimed invention, would have selected these components for combination in the manner claimed." (Emphasis Added). *Id.* Moreover, "the Board must identify specifically the principle, known to one of ordinary skill, that

suggests the claimed combination.” *Id.* Conclusory statements regarding what is “basic knowledge” and “common sense” cannot be used to cure deficiencies of the cited references.

To avoid an impermissible hindsight reconstruction of the prior art, it is necessary “to consider the thinking of one of ordinary skill in the art at the time of the invention and guided only by the prior art references and then-accepted wisdom in the field” (Emphasis Added). *In re Kotzab*, F3d, 55 USPQ2d 1313, 1316 (Fed. Cir. 2000). The motivation, suggestion or teaching to modify the primary reference “may come explicitly from statements in the prior art, the knowledge of one of ordinary skill in the art, or, in some cases the nature of the problem to be solved.” *Kotzab*, 55 USPQ2d at 1317. However, the teaching, motivation or suggestion may be implicit from the prior art as a whole, rather than expressly stated in the references. *Id.* The test for an implicit showing is what the combined teachings, knowledge of one of ordinary skill in the art, and the nature of the problem to be solved as a whole would have suggested to those of ordinary skill in the art. *Id.* If the Board relies on an express or implicit showing, it must provide particular findings related thereto. *Id.* Conclusory statements are not evidence. In *Kotzab*, the court reversed the Board decision because “there was no finding as to the specific understanding on principle within the knowledge of a skilled artisan that would have motivated one with no knowledge of *Kotzab*’s invention to make the combination in the manner claimed.” *Kotzab*, 55 USPQ2d at 1318.

35 U.S.C. § 103 requires consideration of the claimed invention “as a whole.” *Ruiz v. A.B. Chance Co.*, 69 USPQ2d 1686, 1690 (Fed. Cir. 2004). As set forth in this case:

The 'as a whole' instruction in title 35 prevents evaluation of the invention part by part. Without this important requirement, an obviousness assessment might break an invention into its component parts (A + B + C), then find a prior art reference containing A, another containing B, and another containing C, and on that basis alone declare the invention obvious. This form of hindsight reasoning, using the invention as a roadmap to find its prior art components, would discount the value of combining various existing features or principles in a new way to achieve a new result - often the very definition of invention. *Id.*

The discovery of a source of a problem is part of the "subject matter as a whole" inquiry of 35 U.S.C. § 103. *In re Spinnoble*, 160 USPQ 237, 243 (CCPA 1969); MPEP § 2141.02(III). The discovery of the source of a problem can provide the basis of a patentable invention even though the remedy for the problem may be obvious once the source is identified. *Spinnoble*, 160 USPQ at 243. As set forth in *In re Shaffer*, 108 USPQ 326, 329 (CCPA 1956):

In fact, a person having the references before him who was not cognizant of appellant's disclosure would not be informed that the problem faced by appellant ever existed. Therefore, can it be said that these references which never recognized appellant's problem would have suggested its solution? We think not, and therefore feel that the references were improperly combined since there is no suggestion in either of the references that they can be combined to produce appellant's result. (Emphasis added).

In *In re Rinehart*, 189 USPQ 143, 148-49 (CCPA 1976), the court reversed the Board's finding of obviousness because the applied art failed to recognize, and thus did not suggest a solution to, the particular problem encountered by the inventor in scaling up a process disclosed by one of the applied references.

As set forth in *In re Rouffet*, 47 USPQ2d 1453, 1457-58 (Fed. Cir 1998):

To prevent use of hindsight based on the invention to defeat patentability of the invention, this court requires the examiner to show a motivation to combine the references that create the case of obviousness. In other words, the examiner must show reasons that the skilled artisan, confronted with the same problems as the inventor and with no knowledge of the claimed invention, would

select the elements from the cited prior art references for combination in the manner claimed. (Emphasis added).

In *Rouffet*, the court found that the Board failed to rely on the nature of the problem to be solved, the teachings of the prior art, or the knowledge of persons of ordinary skill in the art as a source of motivation to combine prior art references applied in a rejection under 35 U.S.C. § 103, and reversed the rejection. *Id.* at 1458.

The mere fact that a reference may be modified does not make the resultant modification obvious unless the art suggested the desirability of the modification. *In re Fritch*, 23 USPQ2d 1780, 1783-84, n. 14 (Fed. Cir. 1992); *In re Gordon*, 221 USPQ 1125, 1127 (Fed. Cir. 1984); *Kotzab*, 55 USPQ2d at 1316-17; MPEP § 2143.01(I).

## **2. Secondary Evidence of Nonobviousness**

Secondary considerations, when present, must be considered by the Office in the determination of obviousness. See MPEP § 716.01(a). Such evidence of unobviousness can include evidence of superiority of a property shared with the prior art. See MPEP § 716.02(a); *In re Chupp*, 2 USPQ2d 1437, 1439 (Fed. Cir. 1987). Secondary evidence can also include evidence of commercial success. See MPEP § 716.03.

According to MPEP § 716.02(e), a declaration under 37 CFR § 1.132 must compare the claimed subject matter with the "closest prior art" to be effective to rebut a *prima facie* case of obviousness. Applicants cannot be required to compare the claimed subject matter with subject matter that may be suggested by a combination of references relied in the rejection of the claimed subject matter, because this

"would be requiring comparison of the results of the invention with the results of the invention." *In re Chapman*, 148 USPQ 711, 714 (CCPA 1966); MPEP § 716.02(III).

**3. Rejection of Claims 1-9, 11, 13, 14, 39, 41-50 and 56-61**

The rejection of Claims 1-9, 11, 13, 14, 39, 41-50 and 56-61 under 35 U.S.C. § 103(a) over Ni in view of Chang, Murugesh, Arami, Goodyear and Ballance is respectfully traversed.<sup>1</sup>

Claim 1, as amended, recites a plasma processing system comprising, *inter alia*, a plasma processing chamber and a gas injector extending through a dielectric member. The gas injector comprises a body including an axial end surface exposed within the processing chamber, a side surface extending axially from the axial end surface, and a plurality of gas outlets including at least one on-axis outlet in the axial end surface and a plurality of spaced-apart off-axis outlets in the side surface. The off-axis outlets inject process gas at an acute angle relative to a plane parallel to an exposed surface of the substrate. A common gas supply is in fluid communication with a first gas line and a second gas line. The first gas line is in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line is in fluid communication with the off-axis outlets but not with the on-axis outlet. Flow controllers are operable to supply process gas from the common gas supply at flow rates that are independently varied between the on-axis outlet and the off-axis outlets into the processing chamber; and an RF energy source which inductively couples RF energy through the dielectric member.

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<sup>1</sup> Claims 46 and 59 depend from independent Claim 10, which is not included in this ground of rejection. Accordingly, the rejection of Claims 46 and 59 under this ground of rejection is improper.

The claimed plasma processing system provides tunable, multi-zone injection of process gas in the plasma processing chamber. As described at page 9, lines 8-29, of the present application, the plasma processing system provides improved multi-zone gas injection, and hence improved process performance, by allowing the adjustment (tuning) of the ratio of the gas flows through the on- and off-axis outlets of the gas injector. This flow ratio determines the convective flow field downstream from the nozzle tip. The convective flow field can be used to modify the total flow in the chamber, which also includes a diffuse flow component, thereby allowing the spatial density dependence of reactive species to be modulated.

Figures 3a-c illustrate the impact of the injector flow ratio on reactive species densities in an inductively-coupled plasma reactor including a gas injector 22 mounted in an opening in the window 20. See the paragraph bridging pages 13 to 14 of the present application. In the figures, increasing reactant density contours are shown by arrows A and increasing product density contours are shown by arrows B. Figure 3a shows the flow controllers set to direct the gas supply mostly through the on-axis outlet; Figure 3b shows the flow controllers set to direct the gas supply mostly through the off-axis outlets; and Figure 3c shows the gas flow ratio through the on-axis outlet and the off-axis outlets tuned to produce a mixed gas flow.

Submitted herewith is a Declaration by David J. Cooperberg Under 37 C.F.R. § 1.132. Mr. Cooperberg is one of the inventors of the claimed subject matter. In today's semiconductor manufacturing environment, it is necessary to vary gas compositions and flow rates during various fabrication steps, such as photoresist etch, hardmask open, ARC open, dielectric etch, trench etch and gate oxide etch. As discussed at paragraph 6 of the Cooperberg Declaration, most semiconductor



substrate etch processes include multiple, separate etch steps performed on a semiconductor substrate. Multiple steps of the processes are typically performed in the same plasma processing chamber. These different etch steps typically use different process gas compositions and different gas flow rate conditions. It is highly desirable to optimize process performance for these different compositions and flow ratios. For example, to achieve a desired etch uniformity across a semiconductor wafer, different steps of a multi-step etch process may require different center- and edge-zone gas flow rates, i.e., different gas flow ratios. These multi-step etch processes require the gas composition and/or flow ratio to be changed at least once, and typically numerous times, during the process, in a common chamber, in order to achieve the desired etch uniformity for different steps.

As discussed at paragraph 6 of the Cooperberg Declaration, the claimed tunable, multi-zone plasma processing system was designed to address particular problems encountered in semiconductor substrate plasma processing in inductively-coupled systems. More particularly, the claimed plasma processing system was developed to address the problem of performing multiple steps of a multi-step process in a common plasma processing chamber including an RF energy source for inductively coupling RF energy into the chamber to produce a plasma, with optimized process uniformity for the different steps, but without the need for tool modification to perform the steps.

The plasma processing system recited in Claim 1, for example, overcomes this problem. The claimed plasma processing system includes a gas injector that provides tunable, multi-zone gas injection, e.g., center zone and edge zone gas injection, in the plasma processing chamber. The claimed system includes an RF

energy source operable to inductively couple RF energy into the chamber to produce a plasma. The claimed gas injector has at least one on-axis outlet and a plurality of off-axis outlets. The off-axis outlets inject process gas at an acute angle relative to a plane parallel to an exposed surface of a substrate supported on a substrate support within a processing chamber. The claimed plasma processing system also includes a common gas supply in fluid communication with a first gas line in fluid communication with the on-axis outlet but not with the off-axis outlets, and a second gas line in fluid communication with the off-axis outlets but not with the on-axis outlet. The plasma processing system recited in Claim 1 also includes flow controllers operable to supply the process gas from the common gas supply at flow rates that are independently varied between the on-axis and off-axis outlets into the processing chamber. The claimed gas injector is adapted to vary the flow ratio of a common gas mixture through the on- and off-axis outlets.

The gas injection capabilities of the claimed plasma processing system allow the gas flow ratio through the on- and off-axis outlets to be tuned to thereby optimize uniformity of one or more of the plasma and reactive species. The system provides the ability to tune gas injection for optimized performance. The claimed system is adapted for different etch processes, and for different recipe steps within a multi-step etch process, which are performed in the plasma processing chamber and demand different on-axis to off-axis flow ratios for optimum uniformity. The claimed system can provide optimized gas injection for a multi-step process with a single gas injector. As such, the claimed plasma processing system offers efficient and highly versatile performance. This problem is solved by the claimed plasma processing

system, which renders it of great commercial utility in today's plasma etch chambers, as discussed in greater detail below.

**a. A Prima Facie Case of Obviousness Has Not Been Established**

There is no teaching in the prior art of the claimed plasma processing system wherein a common gas source is in fluid communication with (1) a first gas line in fluid communication with an on-axis outlet and (2) a second gas line in fluid communication with off-axis outlets. To remedy this deficiency, the Board Decision cites Arami, Goodyear and Ballance which relate to showerhead electrodes having only on-axis outlets, i.e., there are no off-axis outlets in the Arami, Goodyear and Ballance showerhead electrodes. As such, there is no objective teaching in the prior art of the claimed plasma processing system wherein a common gas source is in fluid communication with (1) a first gas line in fluid communication with an on-axis outlet and (2) a second gas line in fluid communication with off-axis outlets. As such, the Board has erred in affirming the rejection over Chang in view of Murugesh, Arami, Goodyear and Ballance. This same error applies to the new rejection over Ni in view of Chang, Murugesh, Arami, Goodyear and Ballance.

The Board Decision errs in ignoring Applicants' evidence of secondary considerations set forth in the Appeal Brief and Reply Brief. Contrary to the Board's statement that "none of the references contains any disclosure which criticizes, discredits or otherwise discourages a common gas supply . . . ." (Decision at page 12, lines 13-14), Goodyear explicitly teaches away from such an arrangement as follows:

If an identical gas composition is fed via the lines 21 and 22, the present inventors find that (even with adjustment

of different flow rates in the separate supply lines 21 and 22) significant depletion of one reaction gas can occur in the plasma reaction in the gas phase and at the surface of the device substrate 4(14) at a peripheral area of a large area electrode 11, and so non-uniform deposition or etching occurs over the total area. (Emphasis Added, col. 4, lines 48-56 of Goodyear)

Goodyear clearly teaches away from use of a common gas source which would supply an identical gas composition to gas lines 21 and 22. Contrary to this explicit teaching away in Goodyear, the Board Decision errs in stating:

Goodyear recognized the problem of a gas composition containing an ingredient which is easily depleted . . . .  
(Decision at page 10, lines 22-23)

Goodyear is directed to solving a problem caused by use of a common gas source in a multi-zone showerhead electrode. Goodyear states that the problem is the use of a common gas source which causes non-uniform deposition or etching due to depletion of a gas composition ingredient. Goodyear teaches away from using a common gas source which inherently supplies the same gas composition to separate gas lines in fluid communication with separate zones of a showerhead electrode.

The Board Decision errs in its analysis of the Goodyear teaching away from use of a common gas source. The Board Decision states the following regarding Goodyear.

Goodyear . . . would not have taught that the gas composition supplied to the separate sets of outlets must be different . . . . (Emphasis Added; Decision at page 10, lines 22-24).

According to Goodyear, if uniformity is desired, it is necessary to use different gas sources, i.e., not the same gas composition in both zones of the showerhead electrode. As explained above, Goodyear explicitly teaches away from using a

common gas source. Goodyear states that use of the same gas composition supplied to lines 21, 22 causes non-uniform deposition or etching (see col. 4, lines 48-56 of Goodyear). The goal in the art of semiconductor process is greater uniformity, not less.

Goodyear relates to an improvement over an arrangement discussed in the Background of Goodyear wherein "the same gas mixture is fed to both the peripheral and central areas [of a showerhead electrode], but at different rates . . . ." (col. 1, lines 20-53 of Goodyear). Goodyear points out that plasmas are "extremely complex and many of the details of physical and chemical interactions both within the plasma and with surfaces exposed to the plasma are not yet understood" (col. 1, lines 54-57 of Goodyear). The Goodyear inventors discovered that even if flow rates are controlled to peripheral and central areas of a showerhead electrode, "significant non-uniformities can still occur in the thickness, composition and quality of the deposited film" (col. 1, lines 59-62 of Goodyear). Goodyear states that such non-uniformities are more noticeable over large area substrates, and similar non-uniformities can occur in other plasma treatments such as plasma etching (col. 1, lines 63-67 of Goodyear). The Board Decision errs in ignoring Goodyear's teaching away from using a common gas supply, which causes non-uniformity in plasma deposition and etching.

Ballance discloses various showerhead arrangements for rapid thermal processing (RTP) wherein a high intensity light source is used to heat a substrate and a process gas is used to deposit a film (col. 1, line 1 through col. 2, line 62 of Ballance). While such RTP processes are non-plasma film deposition processes, Ballance also includes a discussion of an RF plasma etch system shown in Fig. 8 of

Ballance but that system is identical to the one discussed in the Background of Goodyear, i.e., a showerhead electrode wherein a central zone and peripheral zone are supplied the same gas composition, but at different flow rates. Goodyear explicitly teaches away from using a common gas supply due to its inherent problem of causing non-uniformity problems during plasma deposition and plasma etching. Appellant's evidence of secondary consideration of Goodyear's teaching away has been ignored in the Board Decision. Moreover, there is no teaching in the prior art of the claimed plasma processing system wherein a common gas source is in fluid communication with (1) a first gas line in fluid communication with an on-axis outlet and (2) a second gas line in fluid communication with off-axis outlets. Thus, the Board Decision has not adduced substantial evidence in support of its reconstruction of Chang to replace the injector with the Murugesh injector and further reconstruct the supply lines of Chang to provide for a common gas supply contrary to the teachings of Chang and Murugesh. Given Goodyear's teaching away from using the Fig. 8 common gas supply of Ballance, the rejection over Chang in view of Murugesh, Arami, Goodyear and Ballance is untenable. Likewise, the new rejection is untenable in view of Goodyear's teaching away and the submission of new evidence in the Cooperberg Declaration.

In the new ground of rejection on page 14 of the Board Decision, it is stated that:

we determine that Ni would have disclosed to one of ordinary skill in this art removable injectors as illustrated in Figs. 1 and 3a-c which can have cylindrical and/or conical side surfaces extending axially from an axial end surface, wherein the side surfaces and/or end surfaces can have on-axis and/or off-axis outlets . . . . (Emphasis Added, page 14, lines 18-24 of Board Decision).

However, it is not seen where the Board finds a disclosure in Ni or (1) a “conical” side surface or (2) off-axis outlets in a side surface of the Ni injector. The Board Decision references the discussion of Ni at pages 9-10 thereof but there is no mention of “conical” side surface or of off-axis outlets in a side surface in that discussion of Ni. Absent any disclosure of these features, there is no basis for the new ground of rejection as to independent Claims 1 and 42 (off-axis outlets in side surfaces), or independent Claim 7 (conical side surface having off-axis outlets therein).

There is no basis in the prior art for the Board’s reconstruction of Ni to have separate gas lines supplying the on-axis and off-axis outlets. As explained in the Cooperberg Declaration, the Ni injector is useful for certain processes, such as plasma etching of aluminum, wherein a fixed flow pattern can be used for an entire etching step (Cooperberg Declaration at paragraphs 3 and 5). The Ni injector does not provide required uniformity standards for certain multi-step etch processes wherein the gas composition and flow rates are varied (Cooperberg Declaration at paragraphs 3 and 5). Whereas the Ni injector requires extensive engineering design and experimentation to achieve a fixed flow pattern for a particular etch process (Cooperberg Declaration at paragraph 5), a single design of the claimed injector (which permits adjustment of flow rates to center and edge regions of a substrate) can be used to meet uniformity standards in a variety of multi-step processes whereas the Ni injector can only be designed to meet uniformity standards for a sub-step of such multi-step process.

As set forth in the Cooperberg Declaration, the claimed injector provides superior results compared to the Ni injector. Such superior results are evidence of secondary considerations, which overcome the new §103 rejection.

It is submitted that the applied combination of references does not support the alleged *prima facie* case of obviousness. As discussed above, when a rejection is based on a combination of prior art references, there must be motivation to combine the specific references in the manner claimed. The motivation to combine the references needs to come from one of the three possible sources; namely, from the nature of the problem to be solved, express teachings of the prior art, or knowledge of persons of ordinary skill in the art. *Rouffet*, 47 USPQ2d at 1458. Applicants submit that the Board failed to rely on any one of these sources.

It is submitted that each applied reference fails to recognize, and thus cannot suggest a solution to, the problem of providing a multi-zone gas injection system that can perform multiple steps of a multi-step etch process in a plasma processing chamber including an RF energy source for inductively coupling RF energy into the chamber to produce a plasma, and can achieve optimized process uniformity for the different steps, without the need for tool modification. This problem was recognized by the inventors and solved by the claimed plasma processing system. The discovery of a source of a problem is part of the "subject matter as a whole" inquiry of 35 U.S.C. § 103. *In re Spinnoble*, 160 USPQ at 243.

Ni corresponds to Lam's U.S. Patent No. 6,230,651. The Ni gas injection system shown in Figures 1 and 3A-3C of Ni includes a gas injector 22 in communication with a gas supply 23. The gas injector 22 includes an on-axis gas outlet 46 and off-axis gas outlets 46. Each of the gas outlets 46 is supplied gas from



the gas supply 23 via the single bore 44. In Ni's gas injection system shown in Figures 1 and 3A-3C, because the on- and off-axis outlets 46 of the injector 22 are supplied gas from the same bore 44, the gas flow rate through the on-axis outlet cannot be varied independently of the gas flow rate through the off-axis gas outlets. In other words, the flow ratio of the gas flow rate through the on-axis gas outlet to the gas flow rate through the off-axis gas outlets is fixed.

Ni's gas injection system shown in Figures 1 and 3A-3C does not include the following features recited in Claim 1: **(1)** a common gas supply in fluid communication with a first gas line and a second gas line, where the first gas line is in fluid communication with at least one on-axis outlet but not with off-axis outlets formed in a gas injector body, and the second gas line is in fluid communication with the off-axis outlets but not with the on-axis outlet; or **(2)** flow controllers operable to supply process gas from the common gas supply at flow rates that are independently varied between the on-axis outlet and the off-axis outlets into the processing chamber.

Because there are substantial structural and functional differences between the claimed system and Ni's system shown in Figures 1 and 3A-3C, one having ordinary skill in the art must extensively modify the Ni system to result in the claimed plasma processing system. The extent of this required modification is evidenced by the fact that this rejection relies on five secondary references to modify Ni.

Not only does the Ni injector shown in Figures 1 and 3A-3C lack various structural features recited in Claim 1, Ni fails to recognize the etch uniformity problem solved by the claimed plasma processing system. In fact, Ni discloses that "the gas injector in accordance with the invention can improve etch uniformity,

center-to-edge profile uniformity, critical dimension (CD) bias and/or profile microloading" (page 8, lines 13-15). Ni discloses that "improved etch results can be achieved with a single gas injector located centrally in the upper chamber wall" (page 8, lines 21-22), and that "[t]he number of gas outlets and/or the angle of injection of gas flowing out of the gas outlets can be selected to provide desired gas distribution in a particular substrate processing regime" (page 9, lines 1-3). The effects on gas distribution of the Ni gas injector compared to a gas ring are shown in Figures 2a and 2b of Ni. Figure 4 of Ni shows that the gas injector provides more uniform etch by-product distribution above the exposed surface of a 300 mm wafer as compared to side gas injection (page 11, lines 16-23). Thus, Ni discloses that the gas injector provides improved uniformity.

However, Ni is not concerned with achieving uniformity in different steps of a multi-step etch process using the same injector. Ni discloses that the gas injector is designed to produce desired etching results for a particular substrate etch process that is under consideration. While Ni recognizes that "depending on the etching process, the number of gas outlets, the location of the gas outlets such as on the axial end and/or the sides of the gas injector as well as the angle(s) of injection of the gas outlets can be selected to provide optimum etching results" (page 14, lines 11-14), these specific features of the gas injector make it suitable for a particular process.

For instance, Ni discloses that etching aluminum may require directing the etch gas away from a substrate being etched, while polysilicon etching may require directing the process gas towards the substrate (page 14, lines 3-9). Ni discloses that the gas injector can be specifically designed to have one construction (with no

central gas outlet in the axial end) when used for aluminum etching (page 14, lines 16-23), while the gas injector can be specifically designed to have another substantially different construction (including a central gas outlet) when used for polysilicon etching (see the paragraph bridging pages 14 to 15). Ni does not suggest designing the gas injector to be suitable for both of these processes.

Thus, with extensive engineering design and experimentation, the Ni injector could be used to achieve a desired edge zone flow distribution, or a desired edge and center zone gas flow distribution, for a particular, etch application (e.g., aluminum etch or polysilicon etch). However, because the Ni gas injector structure shown in Figures 1 and 3A-3C is only designed for a single process step, it would be necessary to use different Ni injectors, each having a different structure, for one or more gas flow ratio changes in a multi-step process. This limitation of the Ni injector design makes this injector commercially impractical for performing multi-step processes (see Cooperberg Declaration at paragraph 11). As such, one having ordinary skill in the art would not have been motivated to modify Ni's gas injector to provide a solution to the problem only identified by Applicants.

In contrast to the Ni injector shown in Figures 1 and 3A-3C, the claimed gas injector can be used for various etching processes in a plasma processing chamber. In a multi-step process in which improved etching uniformity may require changes in the distribution of the etch gas in the chamber, the claimed injector enables adjustable gas distribution to maintain desired etch uniformity in each sub-step of a multi-step process. The Ni gas injector does not have such capability because the flow ratio through the off-axis and on-axis outlets is fixed and thus cannot be independently adjusted. Thus, the problem solved by Applicants' invention is not

recognized in Ni and the claimed injector can provide substantially improved results compared to the Ni injector thereby overcoming the §103 rejection over Ni in view of the cited secondary references.

The Board Decision acknowledges that the Chang and Murugesh apparatuses both include more than one gas supply in communication with a gas injector (see the Board Decision at page 7, first full paragraph, regarding Chang, and at the paragraph bridging pages 7 to 8 regarding Murugesh). As such, neither Chang nor Murugesh suggests modifying Ni's gas injection system to include a common gas supply in fluid communication with first and second gas lines, which in turn are in fluid communication with an on-axis outlet and off-axis outlets, respectively.

Chang and Murugesh not only fail to suggest a gas injection system that supplies the same gas from a common gas supply to all on- and off-axis of a gas injector, but also fail to suggest a system that can vary the flow ratio of that gas supplied from the on- and off-axis outlets into a processing chamber. As shown in FIG. 1 of Chang, the top gas nozzle 96 is in fluid communication with the gas source 100a, while the top vent 98 is in fluid communication with the different gas source 100b. The Chang apparatus also includes a gas ring 94 having side gas nozzles 106, 108 extending horizontally through the sidewall of the process chamber. As shown in Figure 1 of Chang, the same gas that is supplied to the top gas nozzle 96 is also supplied to the side gas nozzle 108, while a different gas is supplied to the top vent 98 to bifurcate the gas flow into two different flows (page 18, lines 14-16). Thus, Chang would not have suggested modifying the Ni gas injector shown in

Figures 1 and 3A-3C to be able to supply the same gas from a common gas supply via on- and off-axis outlets, much less at a variable flow ratio.

Murugesh's structure shown in FIG. 3 directs different gases toward different surfaces (i.e., a substrate surface and an inner surface of the chamber wall) in order to process the substrate and clean the chamber. As such, Murugesh, like Chang, does not suggest **(1)** supplying the same gas to on- and off-axis gas outlets of a gas injector; **(2)** optimizing the flow ratio of that same gas to such on- and off-axis gas outlets for a given step of a multi-step process; or **(3)** changing the flow ratio of the same gas supplied by on- and off-axis gas outlets for different steps of such multi-step process to optimize process results for the different steps and thus for the overall process.

Thus, Chang and Murugesh both fail to suggest supplying the same gas to multiple zones via a single gas injector, much less recognize the problem of being able to supply the same gas to multiple zones via a single gas injector and to optimize process results for multiple steps of a multi-step process using a single gas injector.

However, the Board Decision asserts that it would have been obvious in view of Chang, Murugesh, Arami, Goodyear and Ballance to modify Ni's gas injection system to incorporate an annular passage in addition to the central passage (that supplies gas to all of the gas outlets of the Ni injector) to provide separate fluid communication between respective sets of outlets, on- and off-axis, each with its own gas line having a flow controller, to a common gas supply (see the Board Decision at page 15, second paragraph). Applicants disagree.

Arami, Goodyear and Ballance also fail to suggest modifying Ni's gas injection system to result in the claimed plasma processing system. The Board acknowledges that each of these references discloses a showerhead-type gas injection system (see the Board Decision at page 16, lines 6-9). Accordingly, each of Arami, Goodyear and Ballance is an art-recognized different type of gas injector than the injector structures disclosed by Ni, Chang and Murugesh. Despite this fact, the Board asserts that "the injectors of these references along with the cylindrical injectors taught by Chang and Murugesh all establish the knowledge in the art that an injector can be divided into different sections to regulate gas compositions and flow" (see the Board Decision at page 16, lines 9-11).

It is well-known in the art of semiconductor plasma processing that showerhead electrodes have particular constructions and performance characteristics for use in capacitively-coupled plasma reactors. For example, as discussed at paragraph 13 of the Cooperberg Declaration, showerhead-type gas injectors typically have substantially different numbers of gas injection holes, are positioned substantially closer to wafers in plasma processing chambers, and provide substantially different gas flow patterns, as compared to the claimed gas injector. More particularly, as compared to the claimed gas injector in an inductively-coupled (ICP) plasma processing system, showerhead electrodes are used in capacitively-coupled systems. Showerhead electrodes include many more gas outlets, such as a 1000 or more outlets; are conductive and cannot be used beneath a coil in an ICP system; are normally positioned significantly closer to a wafer; and normally provide a sufficiently low gas velocity such that diffusion is the dominant transport mechanism in a processing chamber. Because of these substantial

differences, it is Mr. Cooperberg's opinion that one having ordinary skill in the art would not have selected references in the showerhead electrode art to modify the Ni gas injector, which is used in an ICP system, much less in a manner required to result in the claimed subject matter. This opinion testimony, which is based on well-known differences in the art, is entitled to consideration by the Office. See MPEP § 716.01.

For additional reasons, Arami, Goodyear and Ballance fail to suggest substantially modifying the structure of Ni's gas injection system to supply the same gas to Ni's on- and off-axis injector outlets from a common gas supply. Showerhead electrodes are electrically conductive and unsuitable for use in ICP systems (see Cooperberg Declaration at paragraph 13).

As shown in Figure 2, Arami's apparatus includes a showerhead with gas chambers 37A, 37B and 37C. Each of these gas chambers 37A, 37B and 37C is in fluid communication with all three gas supply pipes 38, 39 and 40, and each gas supply pipe is, in turn, in fluid communication with all three gas supplies 41, 42 and 43. Thus, each gas chamber 37A, 37B and 37C is in fluid communication with all three gas supplies 41, 42 and 43, and the three gas chambers 37A, 37B and 37C are not in fluid communication with only a common gas supply. Arami does not suggest substantially modifying the showerhead such that each gas supply 41, 42, 43 is not in fluid communication with each gas chamber 37A, 37B and 37C.

Accordingly, Arami does not suggest the features of "a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not

with the on-axis outlet," as recited in Claim 1. Thus, Arami does not suggest modifying Ni's gas injection system to include these features.

Goodyear discloses a showerhead including gas supply lines 21 and 22. According to Goodyear, if an identical gas composition is fed via the lines 21 and 22, significant depletion of a reaction gas can occur in the chamber, resulting in non-uniform deposition or etching (column 4, lines 48-56). According to Goodyear, "[i]n many cases, severe process non-uniformities result if the present invention is not employed" (column 4, lines 63-64). As set forth in *In re Fulton*, 73 USPQ2d 1141, 1146 (Fed. Cir. 2004), a reference that criticizes, discredits or otherwise discourages a claimed solution, teaches away from that solution. Because Goodyear criticizes, discredits and discourages supplying the same composition to different zones of the showerhead, which are supplied gas via the lines 21 and 22, respectively, Goodyear expressly teaches away from modifying the structure of Ni's gas injection system to supply the same gas to both the on- and off-axis gas outlets of the gas injector via a common gas supply.

Lastly, Ballance discloses an RTP system for non-plasma deposition. While the Board Decision references Figure 8 of Ballance, showing a showerhead 300 that supplies gas to an inner chamber 308 and an outer chamber 306, Goodyear teaches that such showerhead electrode systems produce undesired non-uniformity results unless separate gas sources are used.

Thus, the applied combination of references does not support the alleged *prima facie* obviousness. None of the applied references recognizes, much less provides a solution to, the problem of achieving uniformity during sub-steps of a multi-step etch process in a plasma processing chamber including an RF energy



source for inductively coupling RF energy into the chamber to produce a plasma.

This problem was recognized by the inventors and solved by the claimed plasma processing system. It is submitted that the failure of the applied references to recognize and solve the problem solved by the invention provides the basis of patentability of the subject matter recited in Claim 1. *Shaffer*, 108 USPQ at 329; *Rinehart*, 189 USPQ at 148-49.

It is further submitted that one having ordinary skill in the art would not have selected elements from any one of Arami, Goodyear and Ballance showerhead electrode systems for combination with the Ni injector in light of the well-known substantial differences between Ni's injector and showerhead electrode systems.

Also, in light of Ni's disclosure that the injector provides improved etch results with a single injector including on- and off-axis gas outlets, in a particular substrate processing regime, the Board Decision fails to establish that the applied combination of references suggests the desirability of the asserted modification of Ni's gas injection system.

Thus, because the applied combination of references does not support the alleged *prima facie* obviousness, the claimed subject matter is patentable.

**b. Secondary Evidence of Nonobviousness**

As discussed above, secondary evidence of non-obviousness must be considered by the Office in its obviousness analysis.

## **1. Evidence of Superior Properties**

The Board appears to have considered Ni to be the "closest prior art" with respect to the claimed plasma processing system. The present application includes evidence of the uniformity problem that occurs when using the Ni injector shown in Figures 1 and 3A-3C and establishes that the claimed tunable, multi-zone gas injector can provide properties not present in Ni. More particularly, the Examples described at pages 19-21 of the present application show results that can be provided by embodiments of the claimed plasma processing system, but not by the Ni gas injection system, which cannot provide adjustable, multi-zone gas flow via on-axis and off-axis gas outlets of the gas injector, and thus does not allow the gas flow ratio between the on-axis and off-axis outlets to be changed during a multi-step process to optimize process uniformity.

According to MPEP § 716.01:

Examiners must consider comparative data in the specification which is intended to illustrate the claimed invention in reaching a conclusion with regard to the obviousness of the claims. (Emphasis added).

The Office must consider these comparative test results in its evaluation of the patentability of the claimed subject matter.

As discussed at paragraphs 8-11 of the Cooperberg Declaration, Examples 1 to 3 show that the flow ratio of the gas flows from the on- and off-axis gas outlets, i.e., predominately off-axis flow, predominately on-axis flow, or mixed on-axis and off-axis flow, that provides optimal results for a given process (which can be a step of a multi-step etch process for a semiconductor substrate) can be substantially different from gas flow ratios that provide the most desirable plasma etch results for

other processes performed in a processing chamber (such as different step of a multi-step etch process).

The test results for Examples 1 to 3 summarized in Table 1 of the Cooperberg Declaration indicate that the best results were achieved by the claimed plasma processing system in the polysilicon etch process of Example 1 using a mixed gas flow, but the best results were achieved by the claimed plasma processing system in both the silicon etch process of Example 2 and polysilicon gate etch process of Example 3 using predominately off-axis gas flow settings.

The comparative test results described in the present application show that the claimed plasma processing system provides a solution to the problem of providing optimized process uniformity in a multi-step process that requires different gas flow ratios for different steps of the process. The comparative test results also provide evidence that the Ni gas injector shown in Figures 1 and 3A-3C, which cannot change the gas flow ratio between its on-axis and off-axis outlets, cannot provide optimized process uniformity for process steps of a multi-step process that require a different gas flow ratio than the single gas flow ratio that the Ni gas injector is designed to provide.

As also discussed in the Cooperberg Declaration, even assuming that the Ni injector can supply a mixed gas flow ratio that provides optimal process results for the process of Example 1, the same Ni injector design could not also provide optimized process results for the processes of Examples 2 and 3, because these processes both require different, predominately off-axis flow conditions to achieve optimal process uniformity. As further discussed in the Cooperberg Declaration, assuming alternatively that the Ni injector can be designed to supply a predominately

off-axis gas flow that provides optimal results for the processes of Example 2 and 3, the same Ni injector would not also provide optimized process results for the process of Example 1. In fact, the Example 1 process off-axis flow conditions provide the worst process uniformity of the three settings.

It is submitted that the comparative data demonstrates the superiority of the claimed plasma processing system with respect to its ability to provide tunable, multi-zone gas injection, which makes the system advantageous for today's multi-step processes, which normally require gas flow ratios and/or compositions to be changed multiple times during a given process. It is submitted that this superiority is sufficient to constitute unexpected results. See *In re Chupp*, 2 USPQ2d at 1439.

c. **The Remaining Claims are Also Patentable**

Independent Claim 7 recites a plasma processing system comprising, *inter alia*, a gas injector including a planar axial end face having an on-axis outlet therein and a conical side surface having off-axis outlets therein, where the on-axis outlet receive process gas from a central passage in the injector and the off-axis outlets receive process gas from an annular passage surrounding the central passage, the gas injector supplies process gas at flow rates that are independently varied between the on-axis outlet and the off-axis outlets into the processing chamber. The system also comprises a common gas supply in fluid communication with first and second gas lines, where the first gas line is in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line is in fluid communication with the off-axis outlets but not with the on-axis outlet. For reasons discussed above, the applied combination fails to suggest the system recited in

Claim 7. Therefore, Claim 7 is also patentable. Claims 44 and 57, which depend from Claim 7, are also patentable over the applied combination of references for at least the same reasons as those for which Claim 7 is patentable.

Independent Claim 9 recites a plasma processing system comprising, *inter alia*, a gas injector including at least one on-axis outlet which injects process gas in an axial direction perpendicular to a plane parallel to an exposed surface of the substrate and off-axis gas outlets which inject process gas at an acute angle relative to the plane parallel to the exposed surface of the substrate, the off-axis outlets being circumferentially spaced apart from each other, the gas injector supplying process gas at flow rates that are independently varied between the on-axis outlet and the off-axis outlets into the processing chamber; and a common gas supply in fluid communication with first and second gas lines, where the first gas line is in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line is in fluid communication with the off-axis outlets but not with the on-axis outlet. For reasons discussed above, the applied combination fails to suggest the system recited in Claim 9. Therefore, Claim 9 is also patentable. Claims 45, 49 and 58, which depend from Claim 9, are also patentable over the applied combination of references for at least the same reasons as those for which Claim 9 is patentable.

Independent Claim 41 recites a plasma processing system comprising, *inter alia*, a gas injector body including a plurality of gas outlets which are disposed within the processing chamber below the interior surface of the dielectric member; a common gas supply in fluid communication with first and second gas lines; and flow controllers, which provide adjustable flow rates of process gas between the on-axis and off-axis outlets into the processing chamber. For reasons stated above, the

applied references fail to suggest the combination of features recited in Claim 41.

Therefore, Claim 41 is also patentable. Dependent Claims 47 and 60 also are patentable over the applied references for at least the same reasons as those discussed regarding Claim 41.

Independent Claim 42 recites a plasma processing system comprising, *inter alia*, a gas injector comprising an injector body including at least first and second gas inlets, at least first and second gas passages, an axial end surface, a side surface extending from the axial end surface toward the interior surface of the dielectric member, and at least a first gas outlet in the axial end surface and a plurality of second gas outlets in the side surface at locations between the axial end surface and the interior surface of the dielectric member, the second gas outlets inject process gas at an acute angle relative to a plane parallel to an exposed surface of the substrate, where the first gas passage is in fluid communication with the first inlet and first outlet, and the second gas passage is in fluid communication with the second inlet and second outlet, and the first and second gas passages are not in fluid communication with each other; a common gas supply in fluid communication with the first gas passages and the second gas passages; and flow controllers providing independently adjustable flow rates of gas through the first and second outlets. For reasons stated above, Claim 42 also is patentable over the applied combination of references. Dependent Claims 48 and 61 also are patentable over the applied combination of references for at least the same reasons as those discussed above regarding Claim 42.

Therefore, withdrawal of the rejection is respectfully requested.

**4. Rejection of Claim 15**

The rejection of Claim 15 under 35 U.S.C. § 103(a) over Ni, Chang, Murugesh, Arami, Goodyear, Ballance and Powell is respectfully traversed.

Claim 15 depends from Claim 1. Powell has been applied in the rejection for allegedly disclosing an electrically conducting shield. Powell also fails to cure the above-described deficiencies of Ni with respect to the subject matter recited in Claim 1. At the least, Powell also does not suggest a gas injector "comprising a body including an axial end surface exposed within the processing chamber, a side surface extending axially from the axial end surface, and a plurality of gas outlets including at least one on-axis outlet in the axial end surface and a plurality of spaced-apart off-axis outlets in the side surface," as recited in Claim 1. Thus, Claim 15 also is patentable.

Therefore, withdrawal of the rejection is respectfully requested.

**5. Rejection of Claims 51-55**

The rejection of Claims 51-55 under 35 U.S.C. § 103(a) over Ni, Chang, Murugesh, Arami, Goodyear, Ballance and Hassan is respectfully traversed.

Claims 51, 52, 53, 54 and 55 depend from Claims 1, 7, 9, 41 and 42. Hassan has been applied in the rejection for allegedly disclosing sonic or supersonic outlets in a gas injector. Applicants submit that Hassan fails to cure the above-described deficiencies of Ni and the other applied references with respect to the subject matter recited in independent Claims 1, 7, 9, 41 and 42. Thus, Claims 51-55 are also patentable.

Therefore, withdrawal of the rejection is respectfully requested.

**IV. Conclusion**

For the foregoing reasons, allowance of the application is respectfully requested. Should the Examiner have any questions regarding this response, Applicants' undersigned representative can be reached at the telephone number given below.

Respectfully submitted,

BURNS, DOANE, SWECKER & MATHIS, L.L.P.

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